DIGESTION AND ABSORBTION OF FOOD

***Digestion can be defined as the biologically hydrolysis of complex food substances into their simple and easily diffusible forms in which they can be absorbed in the gastro-intestinal tract for further utilization*.**

Human digestive system:

Digestive system of man is divisible into-**alimentary canal** and **digestive glands**.

Alimentary canal is a long tube differentiated into **mouth, buccal cavity, pharynx, oesophagous, stomach, small intestine and large intestine.**

Digestive glands are of 5 types-**the salivary glands, gastric glands, liver, the pancreas and the intestinal gland**

1. **Mouth**: Mouth is meant for ingestion of food.
2. **Buccal cavity**: mouth followed by a spacious chamber bounded by two jaws are toothed. The buccal has a roof and is supported by palate. It separates the buccal chamber from nasal chambers. The palate is divided **into hard palate(anterior**) and **soft palate(posterior**), it is called **as uvula or velum palati**. It closes the internal nares during swallowing of food.

The buccal cavity has 2 openings posteriorly**, the dorsal opening is gullet** leading into **oesophagus**, and the **ventral opening is glottis leading into the trachea**. In front of the glottis there is a muscular flap called **epiglottis** which prevent food to enter in **the trachea** during swallowing. Buccal cavity has the following –

(a) Tongue- Tongue has two special structure**- papillae and taste bud**.

Function of tongue---

a. helps in chewing ingested food

b. helps swallowing food

c. tongue perceives sense of taste due to presence of taste buds.

d. helps in speaking.

e. keeps the mouth moist.

(b) Teeth: Both the jaws of man bear teeth.

Structure of tooth A typical tooth is divisible into 3 parts-the **crowns, the neck and the root**. Inside the tooth there is a cavity called pulp cavity, which contain connective tissue, blood vessels and nerves. The pulp cavity lined by a layer of **odontoblast,** the dentine forming cells. The crown is covered by a shining layer called **enamel** while root is covered by cement layer.

Dentition: The arrangement of tooth in the sockets of mammalian jaw bone is called dentition. Four types of teeth are found in man **Incisor, canine, premolar and molar**. They have definite size and shape with definite position and function. This type of dentition with different type of teeth id called **heterodont dentition**. The human teeth are deeply implanted in the deep sockets of jaw bone, such type of dentition is called **thecodont dentition**. In human 2 sets of teeth are found in the life time; the first set is found in young stage called **milk set or deciduous teeth** and second set is found in adult stage is called **permanent teeth**. This type of dentition is known as ***diphyodont***. The number of each type of tooth in upper and lower jaw is represented numerically. It is called dental formula

The dental formula for milk teeth is represented as follows: $\frac{2102}{2102}$ or

{i=2/2, c= 1/1 premolar=0/0 and m= 2/2} = $\frac{5}{5}$ x $2 = \frac{10}{10} = 20.$

At the age of 12 the second molar tooth appears and third molar or *wisdom tooth* appears at the age of 17- 18.

The dental formula of adult man is: $\frac{2123}{2123}$ or

{i= 2/2, c=1/1, pm= 2/2, m= 3/3} = $\frac{8}{8}$ x $2 = \frac{16}{16} = 32.$

i. In herbivorous animal canine teeth are absent hence there is a gap between the incisor and premolar. The gap is called **diastema.**
ii. In elephant **incisor** of upper jaw transform into **huge task**.
iii. **Tusk** of walrus are canine.
iv. In man 20 teeth are diphyodont and 12 teeth are monophyodont.

3. Pharynx: The posterior part of the buccal cavity behind the tongue is called pharynx or throat. It is divisible into **the nasopharynx the oral pharynx (or oropharynx) and the laryngopharynx**.

4. Oesophagus: It is a long muscular tube behind the trachea in the neck region and passes through the diaphragm and finally opens into the stomach in the abdominal region. It acts as an organ of conduction of food and no digestion occurs here.

5. Stomach: It is a thick, muscular J shaped organ present in the left side of the upper part of the abdominal cavity just bellow the diaphragm. The human stomach is divisible into 3 parts-

a. **Cardiac:** This is the anterior part of the stomach into which oesophagus opens through cardiac aperture guarded by cardiac sphincter which prevents regurgitation of food.

b**. Fundic**: - It is main part of the stomach.

c. **Pyloric** stomach: It is posterior constricted part of the stomach opens into the duodenum. It is guarded by pyloric sphincter which prevents the movement of food enter into the duodenum.

The mucous lining also bears gastric glands which secrete gastric juice containing enzyme for digestion of food. It helps in mechanical churning of food.

6. Small intestine: It is longest part of the alimentary canal and differentiated into 3 regions –

a. **Duodenum**- It is the anterior most part of the small intestine having the structure like C, it receives common bile duct, the opening of which is guarded by a sphincter called sphincter of Oddi.

b**. Jejunum**- It is middle part of the small intestine.

c.- **Ileum**-It is the posterior part of the small intestine and opens in the lower part of the abdominal cavity. Villi is present in the mucosal lining of the small intestine. Small intestine is the main part of alimentary canal, where digestion and absorption of food takes place.

7. Large intestine: - It is the posterior part of the intestine and it is divisible into3 parts-

a. Caecum- It is the first part of large intestine, its ends into a tubular structure called vermiform appendix. Sometime, due to decay of food or worm infection, the vermiform appendix elongates and results into a condition called appendicitis.

b. Colon: -colon is divisible into ascending, transverse colon and descending colon. The colon is concerned with conservation of water, sodium of other minerals and formation of faeces.

c. Rectum- It is the terminal part of large intestine with opens into the exterior by an aperture called anal aperture. Rectum is concerned with temporary storage faecal matters.

Physiology of digestion:

Digestion is a process by which food substances are altered physically or chemically so that they are reduced to simple assimilable forms. The process is divisible into two main parts---

Mechanical Digestion-

The phase of digestion comprises liquefying of food by the digestive juices, mastication, swallowing and there after onward movement through the tract by **peristalsis**. It is special muscular contraction by which the food bolus is carried down the oesophagous or any other segment of the alimentary canal. Peristalsis may be defined as a wave of muscular contraction preceded by a wave of relaxation which causes the content of hollow tube. (gastro intestinal tract.) to be passed. onwards. The circular muscles of the digestive tube immediately behind the bolus contract and those directly in front of it relax. This results in the bolus being forced into the relax portion. The contraction of muscles follows closely behind the bolus and further relaxation occurs in front; thus, the bolus of food passes steadily forward.

Chemical digestion

It is affected by chemical substances enzymes present in various digestive juices with which food comes in contact at different levels of alimentary tract.

The digestive juice is secreted in the various part of the alimentary tract are as follow

Saliva in the mouth.

Gastric juice in the stomach.

Bile in the duodenum.

Pancreatic juice in the duodenum.

Intestinal juice (succus entericus) in the small intestine.

Digestion in mouth

When food is taken into mouth it is masticated or chewed by the teeth and moved round the mouth by the tongue and by the muscles of mastication. It is moistened by saliva and formed into a soft mass or bolus ready for deglutition or swallowing.

Saliva – secretion of saliva-

The flow of saliva is controlled by **sympathetic and parasympathetic** nerve supply. The autonomic control of salivation occurs in two ways….

Unconditional reflex- response to the presence of an object, such as food in the mouth (immediately after birth).

Conditional reflex- is something which has been learned from previous experience. The sight, smell and even thought of appetizing food result in salivation sometimes called mouthwatering.

Composition of Saliva

Saliva secretes into the mouth by **three pairs** of salivary glands- **parotids, sub lingual and sub mandibular (rabbit), sub maxillary and sub lingual in man.**

Saliva consists of –

Water 99%,

Inorganic salts (0.2%), NaCl, KCl, Na_2HPO_4, Ca $(PO_4)_2$, KCNS

Mucous (a glycoprotein).

Enzymes- Ptyalin, or salivary amylase, bacteriolytic enzyme lysozyme and lingual lipase.

Function of Saliva-

1. **Digestion** -Saliva contains a starch splitting enzymes, salivary amylase (ptyalin) that acts on cooked starch (polysaccharide) changing them into oligosaccharide, di saccharide, the trisaccharide.

Starch + Ptyalin_-------→ Ca (.

(polysaccharide) α limit dextrins

2. **Lubrication of food**-saliva moistens and lubricates the foods helping the formation of food masses for swallowing
3. **Protection of mouth cavity**-It protects the delicate buccal mucous membrane by moisturing the mouth and by diluting acids and other irritants.
4. **Speech and cleaning**- The mouth keeps constantly moist by the saliva which facilitate speech and cleaning the buccal cavity by movements of the tongue.
5. **Taste**-The taste buds are stimulated by particles present in the food which are dissolve in water. Dry foods stimulate the sense of taste only after through mixing with saliva.

6. **Antibacterial action**-saliva contains antibacterial enzymes 'Lysosomes' kills the bacteria.
7. **Deglutition or swallowing**-Swallowing is a reflex response that is triggered by different impulses in the trigeminal, glossopharyngeal and vagus nerve. Swallowing of food occurs in 3 stages after mastication is completed forms the bolus. The 3 stages as follows---

a. The food bolus is pushed backward into the pharynx by the upward movement of the tongue.
b. The bolus is grasped into the pharynx by the contraction of the contactor muscle into the oesophagus.
c. The bolus food is carried down the oesophagous by involuntary peristalsis, and finally reaches the stomach. Inhibition of respiration and closure of glottis are part of reflex response.

Digestion in stomach

Peristaltic action in the stomach consists of a churning movement which is bought about by contraction of the three layers of muscle fibers. The churning movement further causes mechanical breakdown of food, mixing of food with **gastric juice** and its onward movement into the duodenum.

Gastric juices-

Secretion of gastric juice:

There is always a small quantity of gastric juice present in the stomach, even when it contains no food (fasting juice). There are two phases of secretion of gastric juice…

Cephalic phase- the flow of juice occurs before food reaches the stomach and it is due to reflex stimulation of the vagus nerves following the sight, smell or taste of food.

Gastric phase- When stimulated by the presence of food (mainly protein), the gastric mucosa produced a hormone called gastrin, which passes

directly into the circulating blood. this hormone stimulates the gland in the stomach wall to produce gastric juice.

Composition and function of gastric juice:

In the mucosa of the intestinal wall two types of secretory glands are found…

- **The chief cells**- single layer of secretory cells.
- **Parietal cells-** arranged in layers which secretes directly into the gastric glands and the mixed juice is known as gastric juice.

Gastric juices are clear and pale-yellow fluid of high acidity. The gastric juice contains water, HCl, enzymes- (pepsinogen, renin, and gastric lipase), mucous, inorganic salts etc.

- **Water** -contains 97-99%which helps in liquefies the food swallowed.
- **Hydrochloric acid**- The parietal cells are the source of HCl, and its functions are-

  a. It acidifies the food and stops the action of ptyalin.

  b. Inactive pepsinogen is converted to the active enzyme pepsin.

  c. Acids kills the bacteria ingested with the food and prevent their entry to intestine.

Enzymes-

Pepsin- The chief digestive function of stomach is the parietal digestion of protein. Gastric pepsin produces in the chief cell as inactive zymogen and pepsinogen, which is activated to pepsin by the action of HCl.

$$\text{Pepsinogen} \xrightarrow{H+} \text{pepsin}$$

$$more\ pepsinogen \xrightarrow{auto\ catalysis\ by\ pepsin\ itself} pepsin$$

The enzyme pepsin transforms native protein into proteoses and peptones.

1. $pepsin + protiens \longrightarrow proteoses\ and\ peptones$
2. $pepsin + casinogen\ (a\ phosphoprotein) \rightarrow Casein \xrightarrow{Ca++} Ca\ Paracaseinate(insoluble) \xrightarrow{pepsin} proteoses\ and\ peptones.$

Renin- The enzyme causes the coagulation of milk.

$$soluble\ milk\ protein\ Caseinogen + Renin \rightarrow Insoluble\ Casein \xrightarrow{pepsin} proteoses\ and\ Peptones.$$

Renin is absent in human gastric juice but important in digestive process of calf.

Mucous-It is the glycoprotein which help to neutralized the acid in stomach. The mucous also acts as lubricant and prevent injury to the gastric mucosa by forming coating of mucous.

Inorganic salts-These includes NaCl, KCl, CaCl, Ca (PO_4), etc.

Intrinsic factors-Gastric juice contains intrinsic factors helps in the absorption of erythrocyte maturing factor B_{12} (Cyanocobalamin) which is essential for the proper development of the RBC.in the bone marrow.

Intestinal digestion

The stomach content, or **chym**e, are intermittently introduced during digestion duodenum through the pyloric valve. The pancreatic and bile ducts open into the duodenum at a point very close to the pylorus. The high alkaline content of biliary and pancreatic secretion neutralizes the acids of the chyme and changes the pH of this material to the alkaline side, this shift of pH is necessary for the activity of the enzymes contained in the **pancreatic** and **intestinal juice**. Digestion in intestine can be divided into 3 parts-

1. **Digestion in the duodenum**

The food when passing through the duodenum is exposed to the action of two main digestive juices namely **Bile and Pancreatic juice**.

- **The bile**

Bile is an alkaline viscous, yellow to green bitter fluid(pH8-8.6). The bile is secreted continually by the liver at a rate of0.5 to 1 lit. per day. The gallbladder, a saccular organ attached to the hepatic duct, stores a certain amount of the bile produced by the liver between meals during digestion, the gall bladder contracts and supplies bile rapidly to the small intestine by way of the common bile duct. The pancreatic secretion mixes with the bile, since they empty into the common duct shortly before its entry into the duodenum.

- **Secretion of bile**

Bile does not contain any digestive enzymes but plays an important role in the process of digestion of food. A hormone called **cholecystokinin (CCK**)secreted by the intestine in response to presence of food stimulates the gall bladder to undergo rhythmic contraction to release bile into the duodenum.

- **Composition of bile**

Bile contains water 92%, Bile salts 6%, 0.4% bile pigment, acids, cholesterol and fatty acids.

1. **Bile salts**-Bile contains Sodium taurocholate and Sodium glycocholate. They emulsify, they breakdown of large particles of globules into a suspension of very fine droplets, enzyme Lipase is present. Bile salts control the pH of bile. Bile helps-
    a. Absorption of fat-soluble vitamin A, D, E.K.
    b. React with the insoluble fatty acids salts to convert them into readily soluble substances for absorption
    c. Promotes the secretory power of liver cells.
    d. Bile salts along with bile create an optimum medium for Lipase.

2. **Bile Pigments**- Bile products are waste products formed by the breakdown of hemoglobin of worn-out erythrocytes in the. these are eliminated from the body via intestinal tract. They have functional importance in digestion of food. They are 2 types **Bilirubin and Biliverdin** and presence of these pigments' bile has a distinctive colour.

- **Functions of Bile**: Bile plays an importance role in physiology of digestion-

i. Bile provides medium to dissolve large amount of fatty acid in the intestine.
ii. The alkaline pH of bile provides an optimum medium for pancreatic Lipase.
iii. Bile salts convert large fat globules into fat emulsion.
iv. Helps in absorption fat soluble substances e.g., vit A, D, E and K.

- **Pancreatic juice**: It is secreted by pancreas. It is colourless transparent fluid. Pancreatic juice is alkaline because of presence of bicarbonate of sodium. Human pancreatic juice has a range of pH between7.8-8.4.

composition of pancreatic juice:

pancreatic juice contains water 92% and 2% solid components mainly consist of proteolytic, amylolytic, lipolytic enzymes.

- **Pancreatic enzymes and its functions:**

Proteolytic enzyme-**trypsin, chymotrypsin, carboxypeptidase, Elastases** etc.

Amylolytic enzyme -**Amylopsin**.

Lipolytic enzyme – **Steapsin.**

Nuclease

i. **Proteolytic enzyme:**

Trypsin- it is secreted in its inactive state called **trypsinogen**. It is activated into trypsin by the enzyme **enteropeptidase**. Trypsin acts on the protein and converted into simpler forms of protein such as tripeptides and dipeptides.

$$Trypsinogen \xrightarrow[\text{(inactive enzyme)}]{Enteropeptidase} \underset{\text{active enzyme}}{trypsin}$$

$$Trypsin + Peptones, Proteoses \rightarrow Tri\ and\ Dipeptides.$$

Chymotrypsin: It secretes in an inactive form **Chymotrypsinogen** it is converted into trypsin to form an active enzyme chymotrypsin; chymotrypsin coagulates milk **protein caesinogen** into **casein.**

Carboxypeptidase: Its hydrolases the polypeptides into their constituent's amino acid molecules.

Elastase or Pancreopeptidase: It hydrolyses **elastin** protein to **amino acids**.

a. **Amylolytic enzyme**: Pancreatic amylase **Amylopepsin**, hydrolyses starch into **Maltos**e and **disaccharides**

$$\boldsymbol{Panceatic\ amylase(amylopepsin) + starch\ and\ dextrin}$$
$$\boldsymbol{\rightarrow Maltose + Glucose}.$$

b. **Lipolytic enzyme**: Lipolytic enzyme **steapsin** hydrolases the remaining fats into **fatty acids** and **glycerol.**

$$\boldsymbol{pancreatic\ lipase(stapsin) + Fat\ emulsion}$$
$$\boldsymbol{\rightarrow Fatty\ acids\ and\ Glycerol}.$$

c. **Nucleases**: It acts on Nucleic acids (DNA and RNA) and convert them to **Nucleotides** and **Nucleosides.**

2. **Digestion in the small intestine**:

After pancreatic treatment duodenal contents under goes further digestion in the small intestine. there are 2 types of **intestinal glands Crypts of Lieberkühn and Brunner's gland** and found in the villi of intestine and secretes enzymes. The mixture of enzymes secreted by both glands is called **intestinal juice** or **Succus entericus**.

Enzymes of Intestinal juice and its functions:

Intestinal juice contains Proteolytic, Amylolytic and Lipolytic enzymes.

Proteolytic enzyme- They are erepsin, nuclease, nucleosidase, etc. erepsin is a complex of proteolytic enzymes comprising tripeptidase, dipeptidase and aminopeptidase. These acts on peptides and convert them into amino acids.

Amylolytic enzyme: Intestinal juice contain carbohydrate splitting enzymes sucrase, maltase, lactase. They act upon disaccharides to convert them into glucose.

Lipolytic Enzyme: intestine juice contains fat splitting enzyme called enteric lipase. It act on complete fat digestion.

The food mixture in intestine is called Chyle.

3. **Digestion in the Large intestine:**

Digestion does not occur in large intestine as it does not contain any digestive glands. However, some vegetable cellulose is broken down into carbohydrates by the enzyme secreted by the bacteria living in it. Bacterial enzymes also act on left out protein and fat.

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